Multi-Sensor Composite Melt Maps of the Greenland Ice Sheet for Optimal Detection of Melt

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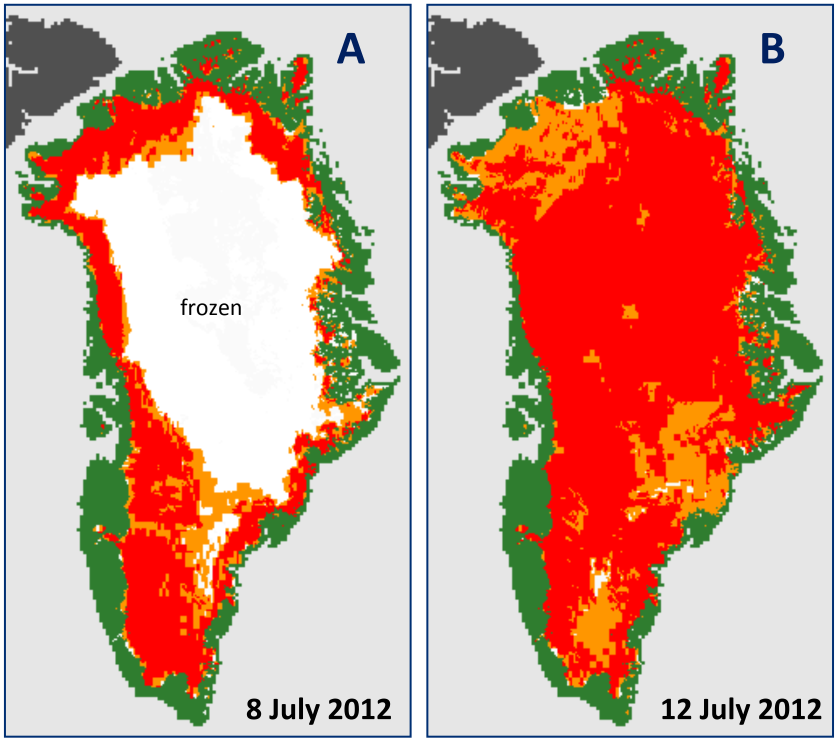


Melt detected with two or more sensors

Melt detected with one sensor only**

Figure 1. Greenland ice sheet melt on (A) July 8 2012 and (B) July 12, 2012 as detected in the IR channel from MODIS, passive microwave from SSMIS and from the scatterometer on Oceansat-2.

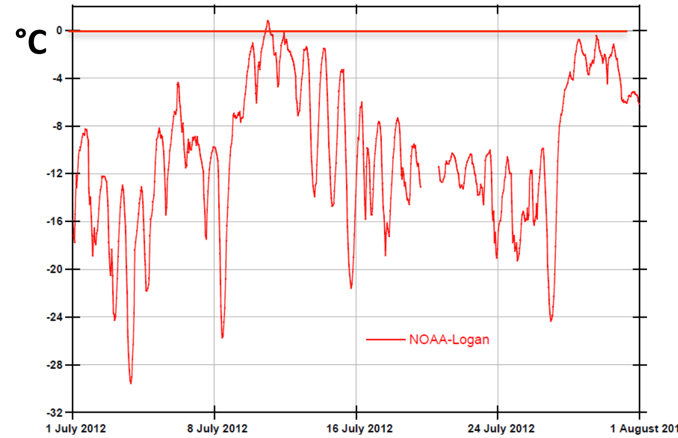
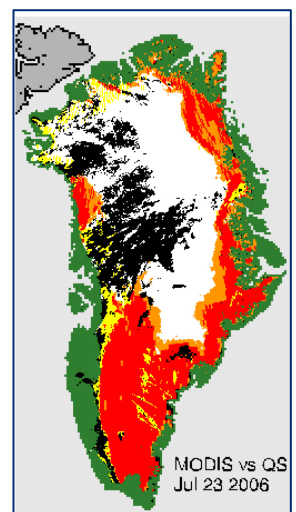


Figure 2. Hourly averaged temperature data from Summit Station, Greenland, showing temperatures above or near 0°C in mid-July and near the end of July 2012. Data courtesy of Tom Mefford, NOAA; graphic created by Mike Schnaubelt and Christopher Shuman, UMBC JCET.



Melt on both

Melt on MODIS only

Melt on QS only

Cloud on MODIS

Figure 3. Difference in Greenland ice sheet melt patterns for July 23, 2006 detected in the IR channel from MODIS and the scatterometer on QuikSCAT.

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Abstract: In this work we combine melt maps of the Greenland ice sheet derived from different instruments. Results generally show agreement but there are areas of the ice sheet where melt maps may disagree on a given day. Sometimes the disagreement is due to the instruments being inherently sensitive to different parameters (e.g., surface melt vs. sub-surface melt). An extreme melt event in mid-July 2012 was captured revealing that >98% of the ice sheet surface had melted. Ice core records indicate that the last time that surface melt was this extensive over the ice sheet was 123 yrs. ago.

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References:
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•Hall, D.K., J.C. Comiso, N.E. DiGirolamo, C.A. Shuman, J.E. Box, and L.S. Koenig, submitted: Variability and trends in the ice surface temperature and surface melt extent of the Greenland ice sheet from MODIS, *Geophysical Research Letters*.
•Mote, T. L., and M. R. Anderson, 1995: Variations in snowpack melt on the Greenland ice sheet based on passive-microwave measurements, *Jour. of Glaciol.,* 41.
•Nghiem, S.V., Steffen, K., Kwok, R. & Tsai, W.-Y., 2001: Detection of snowmelt regions on the Greenland ice sheet using diurnal backscatter change, *Jour. of Glaciol.,* 47(159):539-547.
•Nghiem, S.V. D.K. Hall, T.L. Mote, M. Tedesco, M. Albert, K. Keegan, C.A. Shuman, N.E. DiGirolamo and G. Neumann, in press: The extreme melt across the Greenland ice surface in 2012, *Geophysical Research Letters*.

Data Sources: Moderate-Resolution Imaging Spectroradiometer (MODIS), QuikSCAT (QS), Oceansat-2 (O-2) scatterometer and SSM/I & SSMIS passive-MW data.

Technical Description of Figure 1:
A – Surface and near-surface melt on the Greenland ice sheet on 8 July 2012, and ***B -*** on 12 July 2012 during an extreme melt event that covered >98%of the ice sheet surface. White shows areas of the ice sheet that are frozen, while red shows areas that were mapped as melt on at least two of the three maps and thus represents the greatest confidence; orange represents areas for which only one of the melt maps showed melt. When data from two or more instruments using independent algorithms all detect melt, our confidence in the result is the highest.

The MODIS ice-surface temperature (IST) maps, now available as a climate-quality data record (Hall et al., 2012), are the basis for the MODIS-derived melt maps. QS/OS2-derived maps were generated from an algorithm developed by Nghiem et al. (2001), and the SSM/I-derived melt maps were generated using an algorithm developed by Mote and Anderson (1995). There is some disagreement (see orange in eastern Greenland and yellow in western and northern Greenland) between the MODIS and QuikSCAT melt maps, but that they are in general agreement (Hall et al., submitted).

Scientific significance: Increased melting of the Greenland ice sheet contributes to enhanced sea-level rise. A well-characterized, validated, multi-sensor dataset of ice sheet surface melt will allow us to detect melt trends, if any, that may result from climate change.

Relevance for future science and relationship to Decadal Survey: Using melt maps derived from independent instruments provides more confidence about the amount and location of melt on the ice sheet. Ice sheet models are being developed and coupled to NASA GCMs (GEOS-5 & ModelE). Surface melt will be compared with model-derived melt to improve, calibrate and validate these models to predict meltwater runoff and SLR.

Sensitivity of major crop production zones to recent climate variability: an analysis of 26 years of satellite data

Molly E Brown, Code 618 and Kirsten de Beurs, University of Oklahoma

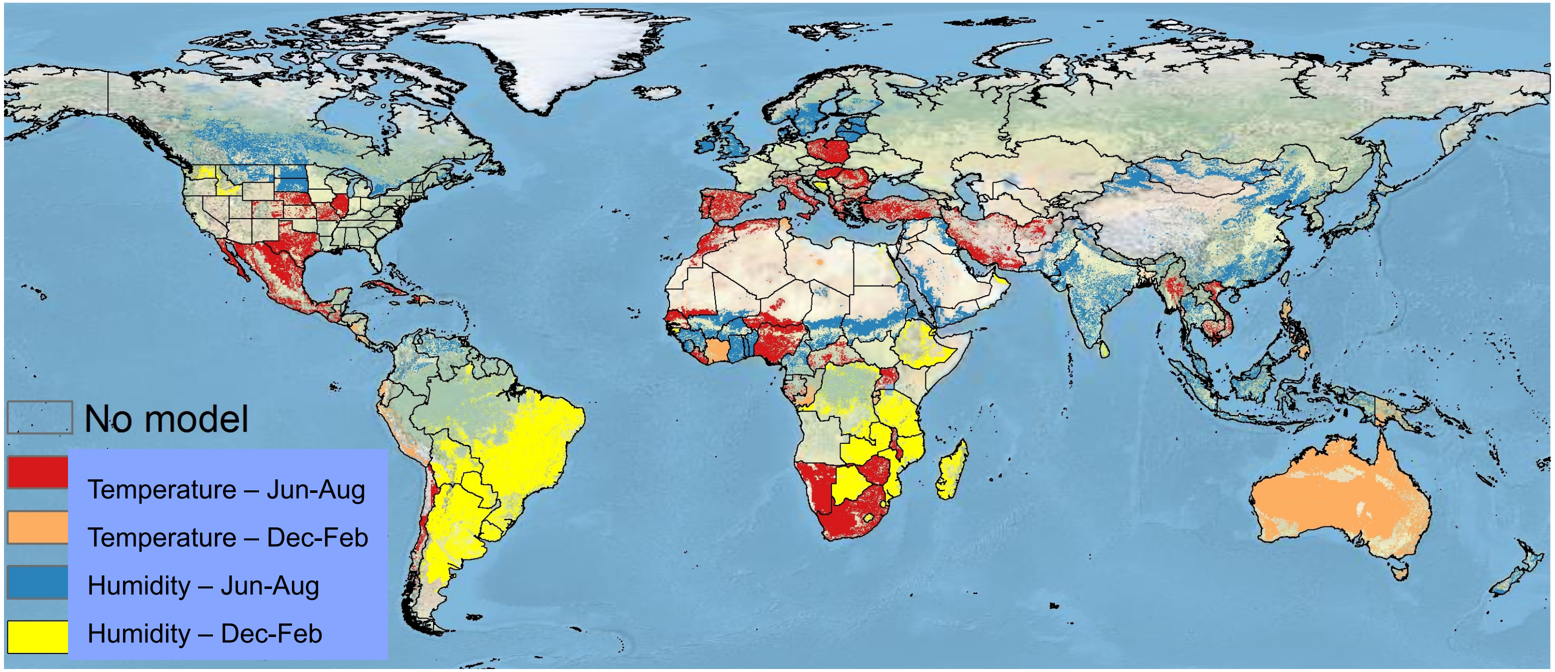

Figure 1. Map shows phenology model results of peak timing of the growing season that best correlate with cereal production statistics.

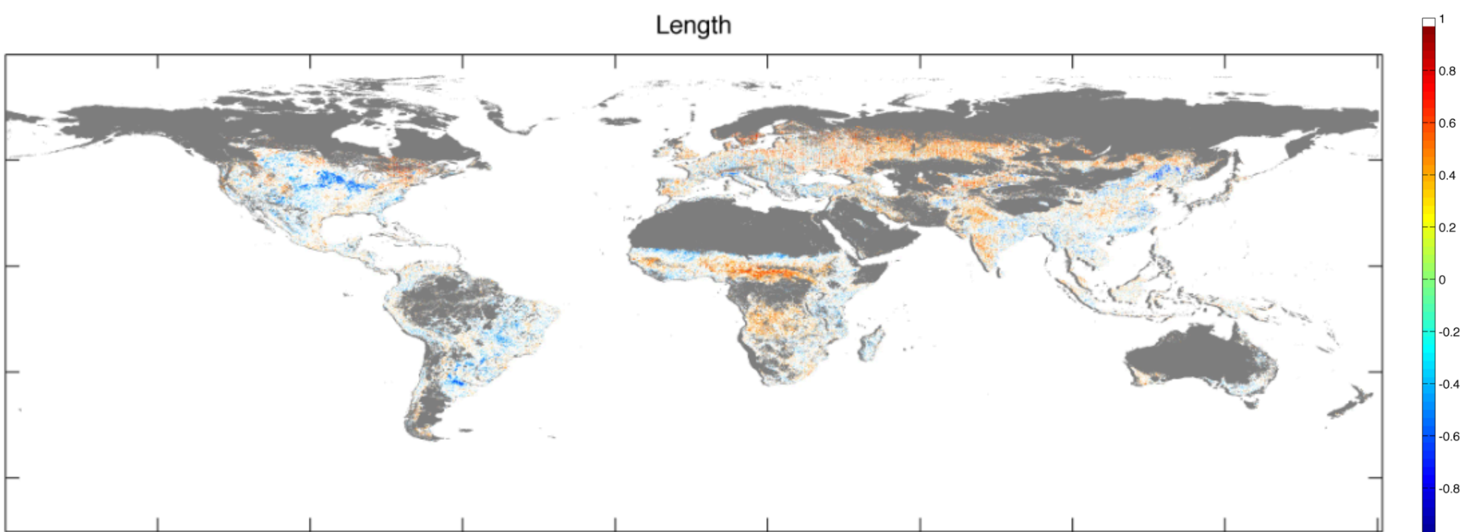

Figure 2. Map shows the significant trends in the length of the growing season from 1982 to 2008. The red colors show areas with longer seasons, the blue colors show shorter growing seasons through time.

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Abstract: The objective of this paper is to estimate changes of agriculturally-relevant growing season parameters, in- cluding the start of the season, length of the growing period and the position of the height or peak of the sea- son, in the primary regions with rainfed agriculture during the past 26 years. Our analysis found that globally, 27% of cereal crop areas have experienced changes in the length of the growing season since 1981, the ma- jority of which had seasons that were at least 2.3 days per year longer on average.

References: **M.E. Brown**, K. de Beurs, M.Marshall (2012) Global Phenological Response to Climate in Crop Areas using Humidity and Temperature Models. Remote Sensing of Environment. *In press*

Data Sources: Vegetation data from the GIMMS AVHRR NDVI dataset from 1981-2006 was used with accumulated growing degree days and humidity data from the Global Land Data Assimilation System (GLDAS) in the growing season analysis. The location of crops globally was estimated using the Monfreda harvested area and yields data created by combining national, state and county level census statistics with a global data set of croplands on a 10 km resolution base map. Agricultural statistics for cereals from 1981-2006 at the country level were obtained from the Food and Agriculture Organization (FAO) and for the United States from the US Department of Agriculture's National Statistics Service (NASS).

Technical Description of Figures:
Figure 1. We analyzed the correlation between cereal production and the timing of the peak of the growing season derived from phenology models including either temperature and humidity for 114 countries around the world. we have four model outputs for each location: relative humidity-NDVI model and the temperature-NDVI model for both cycle 1 (the18-month period from October through March of the following year) and cycle 2 (the 18-month period from April through September of the following year). We found 75 countries for which at least 25% of the pixels behaved differently than expected from the null hypothesis of no correlation. A total of 17 of these countries are located in Europe. Note that we have omitted the countries of the former Soviet Union because we did not have the full production statistics available per country before 1991. Countries that do not reveal a significant model are omitted as well.
Figure 2. Significant trends of Start of Season (top) and length of growing season (bottom) over the 26 years in cropping regions, given by the regression coefficient of the parameter vs time. Significance is measured by p value of less than 0.1.

Scientific significance: The results show significant changes in the timing of phenology in important agriculture regions that has resulted in changes in agricultural production. Recent increases in global commodity prices has revealed that climate, combined with an expanding population and a widespread change in diet from a cereal-based to a meat-based diet may result in an end to an era of predictable abundance of global cereal crops. After a series of floods and droughts, food production in 2011 is not keeping up with demand. Growing conditions in diverse agricultural systems can be observed using the start, length and peak period of the growing season in the cereal producing regions of the world since 1982. Our analysis shows that during the past two decades, climate has had a significant impact on food production, which is likely to become increasingly important as temperatures and moisture conditions change.

Relevance for future science and relationship to Decadal Survey: Future studies will explore the interaction between phenology, food prices and production in countries with agricultural systems vulnerable to changes in the weather. Vegetation and rainfall data can assess variables such as the start of season, growing season length and overall growing season productivity. Here we derive growing season metrics based on land surface phenology models that couple satellite derived vegetation indices with satellite derived evapotranspiration estimates. In future work we will link changes in phenology and agricultural production to annual and interannual price fluctuations in 240 markets distributed over Africa, a region with widespread food insecurity due to low per capita production.